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SUBJECT

INDEXED

WELDING OF MONEL METAL



BY

U. S. NAVAL ENGINEERING EXPERIMENT STATION

ANNAPOLIS, MARYLAND

E.E.S. REPORT NO. 5036-H

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NP16/L5/S29-5 (200)

Serial No. EES-5036-H.

NAVY DEPARTMENT

BUREAU OF ENGINEERING

Report on  
WELDING OF MONEL METAL

BY

U.S. NAVAL ENGINEERING EXPERIMENT STATION  
Annapolis, Maryland.

- NUMBER OF PAGES - Text 8 - Plates 3.
- AUTHORIZATION - Bu.Eng. letter QP/Welding (10-9-Ds) of 21 October 1933.
- DATE OF TEST - From 1 November to 29 December 1933.
- REPORTED BY - Bela Ronay, Sr. Engr. (Welding),  
Head of Laboratory.
- SUPERINTENDENT - A.M. Loker, Lieutenant, USN.
- APPROVED BY - O.L. Cox, Captain, USN, Director.

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Serial No. EES-5036-H.

AUTHORIZATION FOR TEST

1. This test was authorized by Bureau of Engineering letter GP/Welding (10-9-Ds) of 21 October 1933.

OBJECT OF TEST

2. To determine the characteristics of welded monel metal with the object of fabricating feed-water tanks.

ABSTRACT OF TEST

Monel metal sheets were welded with monel metal electrodes to form various types of joints. These joints were tested for physical properties, and corrosion resistance in the salt spray.

A welded assembly in the form of a tank was given an endurance test by subjecting it to pulsating hydrostatic pressure, varying from 350 p.s.i. to 420 p.s.i., during each stroke of the pump.

CONCLUSIONS

Welded monel metal joints - both square butt and T-joints - appear to be suitable for the construction of feed-water tanks.

The deposited metal of the welds seems to have the same corrosion resistance as the base monel metal.

The deposited metal has practically the same chemical analysis as the base monel metal.

RECOMMENDATION

It is recommended that the welding of monel metal sheets with either the square butt or T-joints for fabricating feed-water tanks be approved.

MATERIAL UNDER TEST

3. The material to be welded consisted of 1/8-inch sheets of rolled, annealed monel metal, furnished by the International Nickel Company. The electrodes were 1/8-inch and 3/32-inch diameter, No. 30 arc welding electrodes, also furnished by the International Nickel Company.

METHOD OF TEST

4. Three types of joints were tested:
- (a) The square butt joint.
  - (b) The T-joint.
  - (c) The reinforced T-joint.

Plate 1 shows the diagrammatical illustrations of all three types named above.

The square butt joint.

This joint may be produced by a single bead laid on one side of the joint only. (Plate 1, Figure a) Another form of this joint is produced by laying a single bead on either side of the joint. (Plate 1, Figure b)

The T-joint.

This joint is shown on Plate 1, Figures c and d. This joint may be produced in two ways - the scarf formed by the legs of the T may be filled in with weld metal in a single layer, or it may be filled in with two successive beads.

The reinforced T-joint.

This joint is shown on Plate 1, Figure e. It consists of a common T-joint, reinforced by a butt strap, fillet welded to both legs of the T as shown.

Corrosion Test.

5. Two types of corrosion specimens were prepared - single weld butt joint test specimens in the "as welded" condition, with the slag removed by hand tools in the usual manner, and square butt joint test specimens, welded from both sides, with the excess weld metal ground flush with the base metal. These specimens were subjected to hot salt spray action.

Endurance Test.

6. From the materials furnished, a 12-inch diameter, 36-inch long tank was constructed in the manner illustrated on Plate 2. All joints were welded. The dimensions and design of the welds are shown in detail on Plate 2. This tank was connected to a reciprocating pump with relief valve and piping in the manner shown on Plate 3. The relief valve is so set that the pressure within the tank varies from approximately 350 p.s.i. to 420 p.s.i. during each stroke of the pump. The pump operated at 16 strokes per minute, and the tank was subjected to 30,000 cycles. The longitudinal seam of the vessel is stressed to 20,000 p.s.i. each time the pressure reaches 16 p.s.i. The gage pressure is calculated from the formula given in the General Specifications for Machinery, S48-1-f (2), for thin walled tubes, as follows:

$$p = \frac{2 s t}{D}$$

where  $t = .125"$

$s = 20,000$  p.s.i.

$D = 12"$

hence  $P = \frac{2 \times .125 \times 20,000}{12} = 416$  p.s.i.

The stress of 20,000 p.s.i. gives a safety factor of 3.7 for the longitudinal seam.

DATA RECORDED DURING TESTWelded Joint Tests.

7.

TABLE FOLLOWS:

Type of Joint	Breaking load, p.s.i.	Location of break	Average Joint Efficiency, * per cent
Single bead, single weld, square butt.	77000	Outside of weld	92
	77000	"	
	58000	Partly through weld Partly unfused	
Single bead, double weld, square butt.	76500	Outside of weld	96
	75000	Outside of weld	
	79000	At fusion line	
	75000	Through weld	
Single layer, T	73779	Outside of weld	100
	74011	"	
	73967	"	
Double bead, T	72169	Outside of weld	100
	71807	"	
	72372	"	
	71465	"	
Reinforced T	32575	Through fillet	50
	37892	"	
	67767	"	
	26334	"	
Parent Metal Specimens	77800	-	Average strength 79300 p.s.i. Elongation in 2" 35.2% §
	76000	-	

\* Average joint efficiency is based on this formula:

$$\begin{aligned}
 \text{Total length of weld} &= A \\
 \text{Unfused length} &= B \\
 E &= 100 \frac{100B}{A}
 \end{aligned}$$

#### Corrosion Test.

8. After the lapse of 1200 hours of exposure to the hot salt spray, the following conditions were observed:

The deposited salts could be easily removed by brushing and rinsing, leaving base metal and weld metal practically unstained.

There was no pitting discernible on the base metal, on the weld metal, or at weld zone.

Endurance Test.

9. The welded seams of the all-welded monel metal tank withstood 60,000 stress impulses without leakage or cracking.

DISCUSSION

Square butt joints.

10. The production of square butt joints requires careful assembling - the ends must meet square and carefully aligned. The use of a chill plate under the joint is advisable, a copper chill plate being preferable to steel. The use of a chill plate was found advisable regardless of whether the joint is welded from one side only or from both sides. When welded from both sides, after the completion of the first bead, the chill plate may be discarded. On account of the low heat conductivity of monel metal, even though chill plates are used, the length of each weld increment is limited to a maximum of three inches, if undercutting is to be avoided.

T-joints.

11. T-joints do not require as careful alignment in assembling as the square butt joints. They do not require the use of chill plates and the length of the increments in construction depends on the method of welding used. When the scarf is filled with a single layer the maximum length of each increment should not exceed 2-1/2 inches. When the scarf is filled with two superimposed beads the length of the increment of the first bead is limited to 3 inches; that of the second bead may reach 4 inches.

Weldability, General.

12. All welding should be done in the horizontal, downhand position, with 1/8" diameter electrodes. Unavoidable position welding should be done with 3/32" diameter electrodes only, in order to avoid burning through the 1/8" sheet. Position welding should be limited to vertical or vertically inclined work; overhead welding can not be done with monel metal electrodes.

13. Monel metal electrodes are a specialty. A set of specifications will be submitted separately to cover the requirements for their purchase.

14. Single bead, single weld, square butt joints are capable of developing the full strength of the base metal, when properly made. However, a slight irregularity developing during deposition may result in lack of fusion, which is not discernible by visual inspection. The reinforcement

of the weld reduces its ductility to approximately 25 per cent of the base metal. Single bead, square butt joints, welded from both sides, are more reliable than the single bead, single weld joints. With the reinforcements removed, the ductility of single bead, double weld joints is approximately 40 per cent of the base metal.

15. T-joints, welded with a single layer, are apt to develop the same shortcomings as pointed out in the case of single bead, single weld, square butt joints. T-joints welded with two superimposed beads appear to be the most reliable.

16. Reinforced T-joints are unsatisfactory, as proven by the tests, as they depend on 1/8" fillet welds, which are unsatisfactory for strength.

17. The cost of producing square butt joints is about the same as that of the T-joints, as the time required for aligning the square butt joints and applying the chill plate is roughly equivalent to the time required to form the legs of the T, clamp and tack weld the edges of the T.

18. The single bead, single weld joint requires but one-half the welding time of any of the other joints mentioned, and it is capable of developing the full strength of the base metal. However, it gives the least stiffness to a structure and should not be relied on for strength unless proven by hydrostatic test. The T-joints are capable of stiffening a structure with the addition of the least amount of material, and develop the full strength of the base metal. The double bead T-joint is the most reliable as far as strength and tightness are concerned, without any sacrifice to increased labor and material costs.

#### CONCLUSIONS

19. Welded monel metal joints - both square butt and T-joints - appear to be suitable for the construction of feed-water tanks.

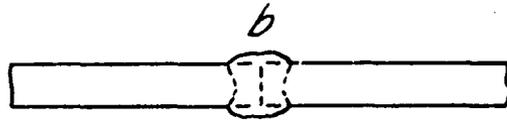
20. The deposited metal of the welds seems to have the same corrosion resistance as the base monel metal.

21. The deposited metal has practically the same chemical analysis as the base monel metal.

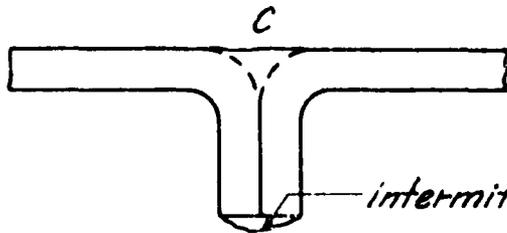
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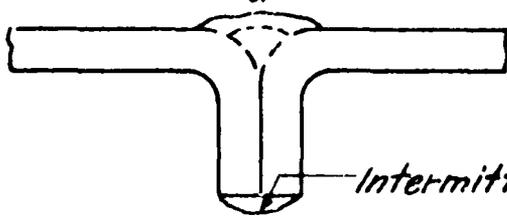
*Single Bead - Single Weld  
Square Butt Joint*



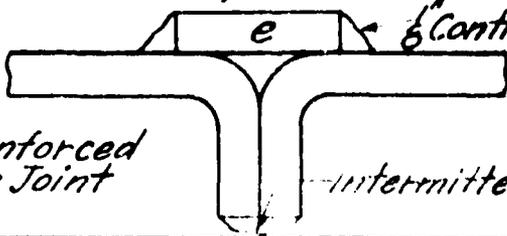
*Single Bead - Double Weld  
Square Butt Joint*



*Single Layer Tee Joint*



*Double Layer Tee Joint*

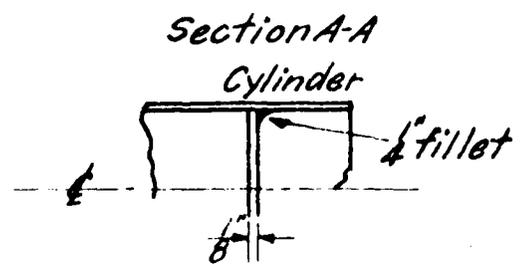
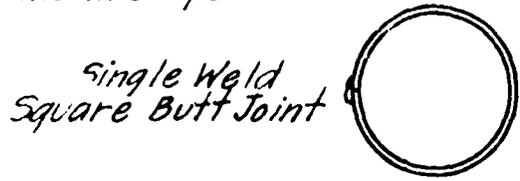
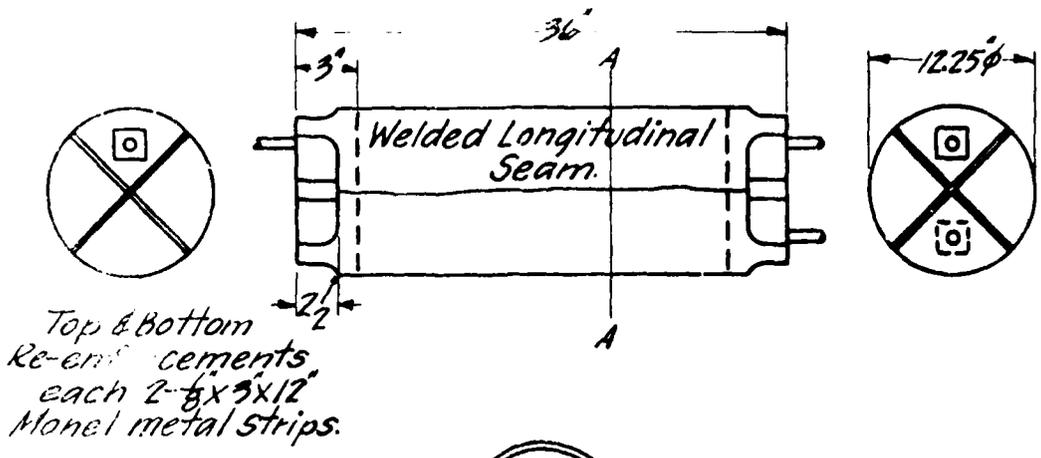


*Re-enforced  
Tee Joint*

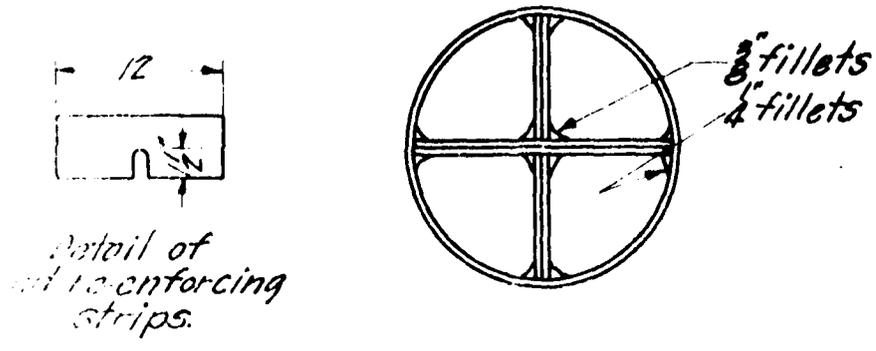
*Continuous fillet weld*

*Intermittent Tack Weld  
Plate*

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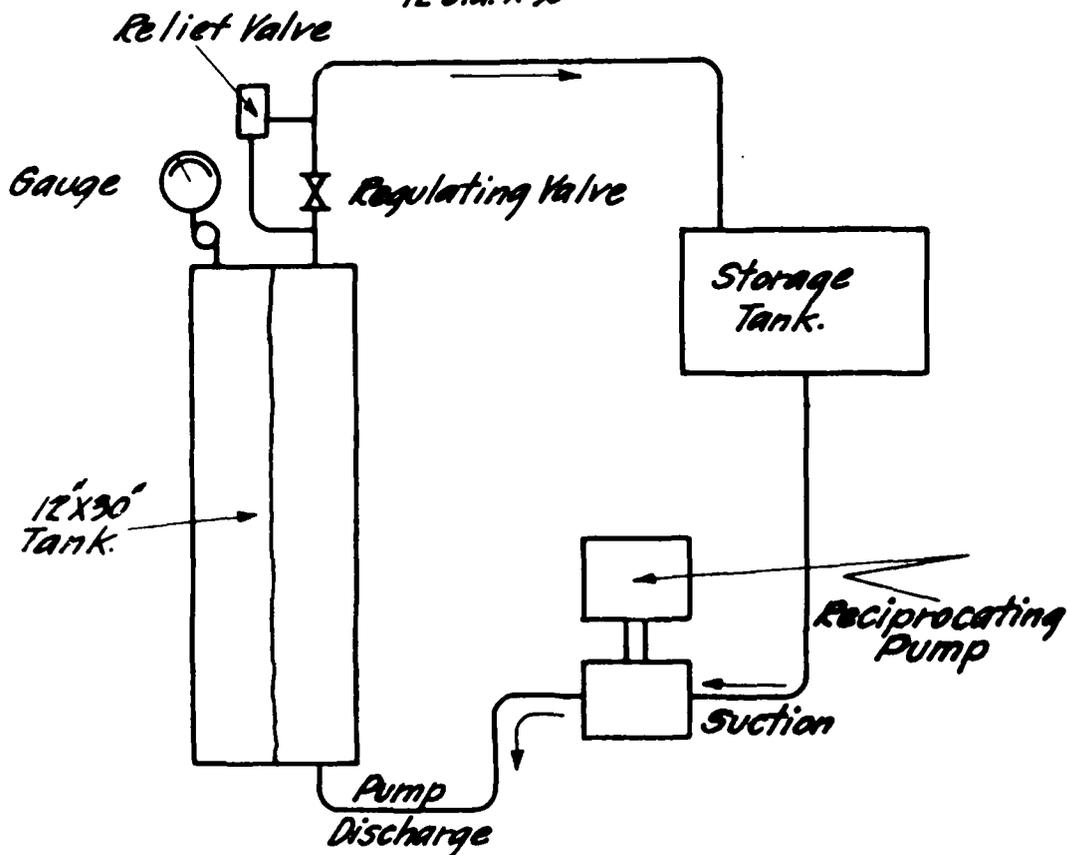


Detail of welding in end plates.



Serial No. EES-5036-H

Schematic arrangement  
of endurance test set up.  
Welded Monel Metal tank.  
12" Dia. x 30"



Note:  
Relief valve opens at 420 p.s.i.  
" " closes at 350 p.s.i.  
Pump speed = 16 strokes per minute.

Plate 3

**END**

**FILMED**

**3-85**

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